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TCS 207.010/68
10 JUL 1968

TOP SECRET - HANDLE VIA TALENT KEYHOLE CONTROL SYSTEM ONLY

From: Oceanographer of the Navy
To: Director, Defense Intelligence Agency (DIAMC)

Subj: World-wide Positioning Requirements

Ref: (a) DIA ltr TCS 657.371-68 of 14 May 68
(b) NAVOCEANO ltr TCS 645.008-67 of 16 Mar 67
(c) DIA ltr TCS 657.220-68 of 25 Mar 68

Encl: (1) Navy Proposed Actions for Refinement of Satellite Ephemerides

1. The Naval Oceanographic Office and the Naval Weapons Laboratory have reviewed reference (a). We have again re-examined the substance of our original proposals in reference (b) regarding the instrumentation of photographic satellites with doppler transmitters and accelerometers for improvement of the Satellite Ephemerides, drag model and gravity model.

2. In reference (a) the Defense Intelligence Agency reiterated the immediate requirement for increased horizontal and vertical accuracies. There is an urgent need for determination of the ephemerides for satellites at 100 miles altitude to a high level of accuracy and a probable future requirement for even higher accuracies.

3. The need for timely action with regard to the projected goals was stressed since lead times will probably result in an incompatibility between the date the requirement is firmly established and the date the requirement must be met. The actions outlined in enclosure (1) reflect our updated thoughts (reference (b)) and are proposed to meet the new requirement stated in reference (a).

4. In the interim period we have further reviewed the possibility of obtaining a short term advantage to be gained geodetically by utilizing as an all MC&G event two J-3 missions with the 3" F.L. DISIC system, one at an inclination at 72° at a 90-115 nm altitude to be totally independent of any intelligence collection missions. This mission will provide geodetic ties between South America and the United States. A second geodetic mission should be at an inclination of 83° and provide the necessary short arc ties with Europe-Africa.

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These lower inclinations will provide better photogrammetric short arc solutions when supported by existing ground control data and known datums. One of the major contributing causes in not meeting the 750 ft. accuracy is the failure of having a dense geodetic network that is photo identifiable.

5. In the matter of the New Search developments, reference (c), it is strongly recommended that consideration be given to instrumenting several 12" F.L. systems with the doppler transmitters as part of the post-1970 period geodetic satellite program. The availability of approximately 20 geoceivers should be well established and coupled with the retention of the present Tranet System (20) (13 stations augmented, 4 mobile Vans, and 3 SRN/9 receivers) stations provide the means for accurate ephemerides determination and control densification.

6. The TIMATION ranging technique (item g, enclosure (1)), a part of the Advanced Navigation System Analysis, has the advantage of being capable of providing continuous coverage if satellites at synchronous altitudes are employed or it can provide intermittent coverage using a single satellite at low altitude. The development potential of a combined Doppler/Timation system may provide techniques for continuous geodetic, all-weather instantaneous fixes on a world-wide basis.

7. Recommendations and Summary. Proposals (a), (b), (c), and (f) of enclosure (1):

a. Doppler Transmitter in Low Altitude Satellite

b. Accelerometers in Low Altitude Satellites

c. Geoceiver Deployment

f. Satellite Acquired Doppler Observations

should be pursued to assure that the immediate accuracy objectives are met, to provide some possibility that the long range objectives can be met, or to at least provide some source data to assist in meeting these long range objectives. Proposal (e), Improvement in Gravity Field, should be given high priority to provide assurance that long range accuracy requirements are met and that source data for follow-on systems are available. Proposal (f), Satellite Acquired Doppler Observations, should be given the highest priority as a means of achieving an even higher degree of precision than that possible under (e), although in a system subject to accidental or deliberate jamming.

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Proposals (d) and (g):

d. Remote Geoceivers

g. Satellite Acquired Timation Observations

should be reserved in the event that more promising methods fail to meet requirements. Component development of these systems should be pursued and the decision reviewed periodically.

8. The proposals as outlined within the enclosure reflect Navy's engineering concepts which it could further investigate and implement, provided that a valid requirement is established and approval and funding furnished. Within the scope of the proposals there is no intent to bring any of these, which by themselves are at a much lower classification--or may even be unclassified--under the aegis of the Talent-Keyhole System. The Navy's Geophysical Satellite program, basically a navigation system, is now available to U. S. commercial interests. We must reiterate that the techniques described are recommended instrumental means within the R&D concept to achieve the desired world-wide positioning requirements. There is no intent to infringe, nullify or limit the scientific application of any current satellite efforts which may parallel, coincide or complement these proposals if they are investigated in support of objectives of the Talent-Keyhole System.

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DEPARTMENT OF THE NAVY - PROPOSED ACTIONS

a. Doppler Transmitter in Low Altitude Satellite

This recommendation has been made by the Defense Intelligence Agency and the Air Force Space and Missile Systems Organization. COL Courtney of SAMSO indicated that the Air Force Secretary for R&D has questioned whether the action would provide assurance that the immediate accuracy requirements would be met. The NWL is reviewing available information to determine what degree of assurance can be given; however, the fact that the Doppler system will improve the accuracy of the current system, which has not been able to achieve the accuracy objective, should be sufficient justification for its use.

b. Accelerometers in Low Altitude Satellites

Accelerometers have been flown in engineering models of low altitude satellites with excellent results according to the project personnel. We reiterate our recommendation of two years ago that accelerometers be flown with the Doppler transmitters. The accelerometers not only help directly by reducing errors due to drag and thrust uncertainties, but also indirectly by permitting analysis of longer time spans of data, thus reducing the effects of observational errors and allowing more thorough study of, and subsequent correction for, gravity errors.

c. Geoceiver Deployment

Assuming Doppler transmitters are incorporated in the low altitude payload, all available Geoceivers should be deployed to obtain data from the satellites because the portion of the orbit seen by each observing station is extremely small at low altitudes. The NWL is conducting studies to determine the optimum deployment of Geoceivers which can be directly assigned to the project; coordination with other purchasers of Geoceivers is also recommended.

d. Remote Geoceivers

An obvious method of achieving the long range accuracy, despite the small portion of the orbit of low altitude satellites seen by each observing station, is by large scale deployment of Geoceivers. Surface ships, submarines, and heliocopters could be used to deploy Geoceivers with automatic or pre-programmed signal acquisition capability on reefs, the ice cap or as anchored buoys, recovering the data tape one to two weeks later. Although some portion of the equipment would be lost to the elements or to vandalism, the accuracy objective would be achieved by using the high altitude satellite data to determine the position of

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the equipment and the low altitude data to determine the desired orbit information. Although the equipment cost for this project would probably be less than that for the proposals which follow, it is not recommended that this course be pursued at any significant level of effort. The investment in personnel, ships, aircraft and the possible confrontation with unfriendly forces, coupled with the poor growth potential, make this approach appear inferior to those below. However, the lead time is smaller than that for those below, and it may therefore prove to be the only alternative for a given time schedule. Similarly, satellite relay of the data acquired by the remote Geoceivers is tentatively ruled out, since the lead time would be increased to the level of that for a more effective system below.

e. Improvement in Gravity Field

The Naval Air Systems Command has submitted a plan for the improvement in the earth's gravity field with the aid of data obtained from five proposed satellite launches, four of which would contain drag compensating thrusters. Accomplishment of this program will provide valuable and possibly vital data for the long range accuracy requirement. The improved gravity field, together with development of the thrust compensation techniques, will further provide a unique capability for jam-proof, US-based, real time orbit determination and prediction for follow-on systems. A high priority should therefore be given to this development proposal.

f. Satellite Acquired Doppler Observations

During the time a ground station observes a satellite at 600 statute miles travel from horizon to horizon, the satellite traverses 60 degrees in central angle (in latitude, for a polar orbit). A 100 mile satellite traverses only 24 degrees, which results in the poor coverage discussed earlier, particularly considering that a larger percentage of these data are subject to large refraction errors. On the other hand, if a 100 mile satellite were observed from a 600 mile satellite, the lower satellite would be in view during 84 degrees of central angle, more or less depending on whether the relative motions were in the same or in opposite directions. On an area basis alone then, tracking data from one 600 mile satellite would be worth

$\frac{(84/2)^2}{(24/2)^2} =$ 12 ground stations. This ratio, which in itself would be cost

effective if development costs were ignored, is very conservative because the percent gain is greater when refraction effects are considered, because it may be possible to optimize the orbits to increase the effectiveness, and, most particularly, because data could be acquired during portions of the orbit which are otherwise inaccessible. The Naval Weapons Laboratory will

conduct studies to evaluate orbit accuracy for various configurations of tracking satellites. The Naval Air Systems Command should be urged to initiate an urgent project at the Applied Physics Laboratory of Johns Hopkins University to develop a 600 nautical mile satellite equipped with geoceiver type acquisition and tracking equipment and with a navigation satellite type memory to record the tracking data for read-out at telemetry stations. Capability for tuning the satellite receiver over a reasonable range of satellite off-set frequencies would be required in order to prevent jamming.

g. Satellite Acquired Timation Observations

The possibility of applying the Timation System under development at the Naval Research Laboratory in the mode described in paragraph (f) above for the Doppler system should be borne in mind during the course of the NRL project. The Timation System offers the promise of greater coverage with the use of synchronous satellites and higher potential accuracy since geometric solutions for satellite position can be made with range measurements from three satellites, thus eliminating effects of drag and gravity errors on the low altitude satellite. One disadvantage is the singularity at the equator, which could probably be bridged easily with orbit computations based on dynamic techniques. The principal disadvantage is that the system has not yet been developed to the point of demonstrating a level of accuracy comparable to the Doppler system. Development of the system components should be pursued as a possible alternative to the Doppler system proposed in paragraph (f).